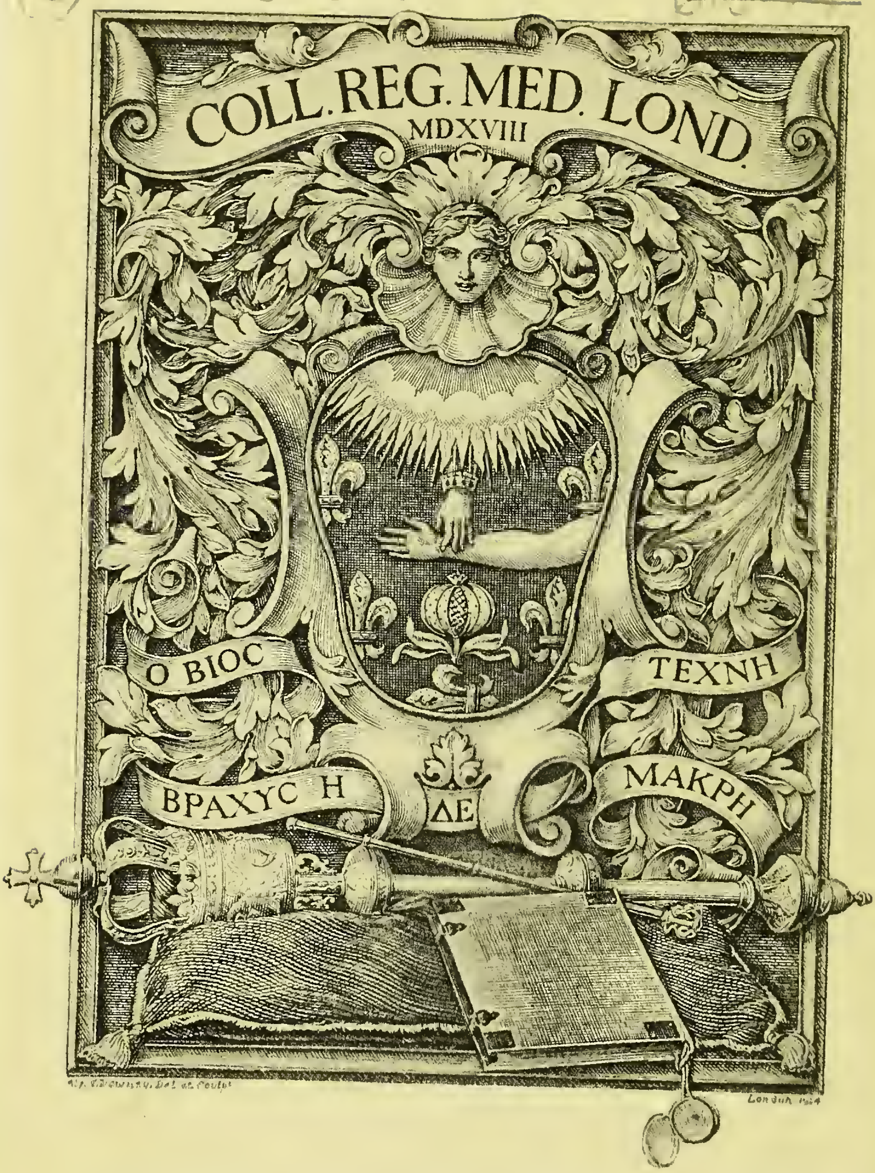
D2/86-C-5



Digitized by the Internet Archive
in 2016

https://archive.org/details/b28523349

From the Author.

128/58

Philip. (A P.W)

AN

ANALYSIS

OF THE

MALVERN WATERS.

BY

A. PHILIPS WILSON, M. D. F. R. S. Ed.

Fellow of the Royal College of Physicians of Edinburgh, &c.

WORCESTER:
PRINTED AND SOLD BY J. TYMBS;
AND BY W. SMART:

SOLD ALSO BY CADELL AND DAVIS, STRAND; MURRAY, FLEET-STREET; CROSBY AND CO. STATIONER'S-COURT; CALLOW, CROWN-COURT, PRINCE'S-STREET; COX, BOROUGH, LONDON:

AND BY BELL AND BRADFUTE, EDINBURGH.

1805.

ROYAL COLLEGE OF PHYSICIANS LIBRARY	
CLASS	615.79
ACCN.	18902
SOURCE	
DATE	

CONTENTS.

SECT. 2.

ERRATA.

INTRODUCTION—Page x, l. 8, for , read . and l. 9, dele *or.*
Page 25, l. 8, for *was* read *were.*
—— 48, l. 10, for *was* read *were.*
—— 58, l. 1, after *contents* insert *of a gallon.*

INTRODUCTION.

THE Malvern waters have long been celebrated for their purity, and to this alone their effects have generally been afcribed. From the following Analyfis of thefe waters, however, it would appear that this opinion is erroneous, and that their good effects, as in the cafe of other mineral waters, arife chiefly, at leaft, from the foreign ingredients they contain. This will hardly be doubted if it can be fhewn that they contain fubftances which have long been celebrated medicines in the fame difeafes in which the effects of the Malvern waters are fo ftrikingly beneficial.

That they contain but a fmall quantity of fuch fubftances is no argument againft this opinion. We well know that the effects of medicines are not in proportion to the dofe merely, but are influenced by a variety of circumftances, with fome of which we feem to be but ill acquainted. How many chalybeate fprings, which contain but a fmall quantity of iron, are more efficacious in reftoring vigour than the moft powerful artificial chalybeate; yet we know

 that

that the effects of ſuch waters depend on the iron they contain, becauſe, when deprived of it, they loſe at the ſame time their invigorating quality. Whether the ſame quantity of iron diſſolved in the ſame quantity of pure water, would produce the ſame good effects, independently of the other ingredients of ſuch waters, we cannot tell. Moſt probably it would not. But when we reflect on the intimate union which takes place between bodies, when one exiſts in very great, and the other in very ſmall quantity, of which a thouſand inſtances might be enumerated, we have ſome reaſon to ſuppoſe that the effects of many mineral waters depend on this intimate union, by which perhaps a greater quantity of the medicine is received into the ſyſtem, or is received in a ſtate more capable of producing its peculiar effects than when it is taken into the ſtomach and bowels in a more concentrated form.

To the numerous caſes proving the efficacy of the Malvern waters, given by Dr. John Wall,* I might, were it neceſſary, add ſome equally ſtriking which have fallen under my own obſervation.

The complaints in which theſe waters have been chiefly celebrated are the various forms of

* See seventy-six cases of their efficacy related by Dr. John Wall, in his Medical Tracts, re-published by Dr. Martin Wall in 1780.

Scrophula,

Scrophula, Cutaneous difeafes of different kinds, and Gravel.

Dr. John and Dr. Martin Wall * are the principal writers on the Malvern waters. It feems to have been the opinion of both, that the effects of thefe waters are chiefly to be afcribed to their purity. " The efficacy of this water," the former obferves, " feems chiefly to arife from " its great purity, whereby it paffes through the " fmalleft veffels, and not being loaded with " any falts or earth, it is capable of diffolving " more than thofe waters which are already fa-" turated with them. Its effects externally, " both in lotion and bathing, may in a great " meafure depend upon the fame; fince it is " paft all doubt that fluids may enter the body " this way by the abforbing veffels." † And Dr. Martin Wall, in his Appendix to Dr. John Wall's Obfervations, remarks, " Its principal virtue

* There are two springs in the Malvern hills which have been celebrated, and are supposed to be of the same nature. The one is called the Holy-well, the other St. Ann's-well. The experiments of both Dr. J. and Dr. M. Wall were made with the water of the former. There are also some chalybeate springs in the neighbourhood of the village of Malvern, the analysis of which I have begun, and shall lay before the public as soon as I have had leisure to finish it. To Dr. Wall's Tracts I refer the reader for an account of the situation of the Malvern springs, and of the nature of the hills from which they issue.

† See the above mentioned Tracts, page 117.

" then

" then muſt depend upon its extreme purity, " aſſiſted by the fixed air which it contains."*

Dr. John Wall, however, was led by ſeveral obſervations to doubt the juſtice of the popular opinion. " It has been the opinion of ſome " perſons," he obſerves, " that the water of " the Holy-well is only pure element, devoid " of mineral ſpirit and almoſt all other princi- " ples. Indeed were this the caſe, which for " many reasons I am convinced it is not, " that purity alone would make the spring of " great value." After a quotation from Hoff- man, Dr. Wall continues, " I have inſerted this " quotation from an author of the greateſt " eminence, in order to ſhew what might be " expected from a pure water, and ſurely no " ſpring can more juſtly deſerve the title than " this does.† But that there is alſo a fine ſubtle " penetrating ſpirit concealed in theſe waters, " agreeable to what is mentioned in the fore- " going treatiſe, is evident from the following " obſervations. The firſt of theſe was commu- " nicated to me by my very ingenious friend, " Dr. Mackenzie, who informed me, that he

* Page 288.

† Dr. Martin Wall, we shall find, has shewn that Dr. John Wall was deceived with respect to the quantity of the foreign contents of this water. It is certain, however, that compared even with the springs in common use, it must be considered a very pure water.

" knows

" knows a gentleman in Warwickſhire who has
" a cancerous ulcer in his face, which he uſes
" to bathe every day with Malvern water before
" he applies his other dreſſings to it. The wa-
" ter, when uſed alone, frequently makes the ulcer
" ſmart to a degree, which he is not able to bear
" till he adds a certain proportion of common
" water to it; but when the Malvern water is
" thus diluted with river or other water, he
" can bear it very well.

" This remarkable obſervation has been ſince
" confirmed to me by Dr. Turton, a very eminent
" Phyſician, of Birmingham, who himſelf alſo
" felt a very ſenſible effect from this water, dif-
" ferent from that of a common ſpring. He
" has lately had a putrid fever, attended with
" ulcerations on the throat and tongue, which
" left the parts very tender: upon waſhing his
" mouth with this water, and drinking a glaſs
" of it at the ſpring head, he felt great pain and
" ſmarting in all the parts which had been ul-
" cerated: however he continued to waſh his
" mouth frequently, the uneaſineſs gradually
" leſſening upon every lotion; and he drank
" large quantities of the water that whole day.
" The next morning he found his mouth and
" throat quite easy and free from any tender-
" neſs, which it had never been before ſince
" his illneſs."

Before relating my experiments and conclu-
ſions,

fions, it will be proper, in order to avoid confufion, to point out thofe of Dr. John and Dr. Martin Wall, which feem to contradict them, and the circumftances which reconcile thefe contradictions.

Dr. M. Wall has noticed what appears to be a principal caufe of Dr. J. Wall's having obtained fo fmall a refiduum from the Malvern water by evaporation, namely, that he performed the evaporation in open veffels. It will appear, from the experiments I fhall relate, that fome part of the folid contents of this water, if the diftillation is not performed very flowly, comes over with the water, even when it is performed, as Dr. M. Wall advifes, in a retort and receiver luted together.

Dr. J. Wall was led to believe, that the Malvern waters contain fulphuric acid in a difengaged ftate. "The water of the Holy-well, "when drank immediately as it comes out of "the hill, leaves a peculiar tartnefs in the "throat. This is by fome likened to the tafte "of brafs or alum, and is moft perceptible to "thofe who have not been ufed to the water; "but this tafte is foon loft, and the water grows "fofter after it has been kept fome time, though "the bottles be ever fo carefully ftopped. With "this water either acids or alkalis mix without "the leaft alteration in tranfparency, and with-"out any precipitate or conflict; and yet it

"feems

" ſeems to contain a concealed acid, becauſe " iron laid in the water is corroded; and with a " ſolution of silver, though at firſt it mixes " without any milkineſs, yet, by standing ſome " time, the water grows gradually whitiſh, and " then muddy, and of a dirty reddiſh purple; " and at laſt a powder, of a deep purple colour, " is precipitated, which is the effect of the " vitriolic acid."*

Dr. M. Wall attributes this precipitate to carbonat of lime; it ſeems not, however, to proceed either from this or the ſulphuric acid. Dr. M. Wall juſtly obſerves, that, if it aroſe from the preſence of ſulphuric acid, infuſion of litmus and ſyrup of violets would give evidence of acidity, which they do not. With reſpect to the carbonat of lime, Dr. M. Wall ſeems to have been miſled by his correſpondent, who ſays, that no turbidneſs takes place on the addition of a ſolution of nitrat of ſilver, after the water has been diſtilled in cloſe veſſels, although acetat of lead occaſions a precipitate. I have always found the turbidneſs to take place on the addition of nitrat of ſilver, when a precipitate could be obtained by acetat of lead.

Were Dr. M. Wall's explanation juſt, the turbidneſs ſhould be prevented by the previous addition of nitrous acid to the water, which is

* See Dr. J. Wall's Tracts, pages 116 and 117.

not

not the caſe, unleſs the water has been diſtilled. Besides, there is no precipitate on the addition of oxalic acid, whether the water has been diſtilled or not.

Dr. J. Wall ſtates, as another proof of the exiſtence of a diſengaged acid in theſe waters, that effervescence enſued on mixing the water of the Holy-well with a ſaturated ſolution of carbonat of potaſs. The way in which the experiment was made* sufficiently points out that the appearance of effervescence aroſe merely from the extrication of air with which all waters are impregnated. A far leſs quantity of acid than is neceſſary to occaſion any degree of effervescence would affect the above mentioned teſts of acidity.

Carbonat of ammonia has alſo been ſuppoſed to exiſt in the Malvern waters, and one of Dr. M. Wall's correſpondents thought he had aſcertained its preſence, as indeed there was reaſon to believe, when he found that after diſtillation this water gives a precipitate with acitat of lead. Dr. M. Wall refers to another experiment of the ſame correſpondent, in which he found that the nitrat of silver occaſioned no precipitation nor turbidneſs in the diſtilled Malvern water, which Dr. M. Wall juſtly obſerves it ſhould have done, had this water contained an alkali; but in

* See Dr. J. Wall's Tracts, page 132.

this

this experiment there ſeems to have been ſome inaccuracy, for, as I have juſt obſerved, the Malvern waters, though diſtilled in cloſe veſſels, may ſtill give a precipitate with nitrat of ſilver, a circumſtance which tends to invalidate Dr. M. Wall's explanation of the precipitate from the diſtilled water by acetat of lead, namely that it ariſes from the water retaining its carbonic gas after diſtillation, which we cannot ſurely ſuppoſe. But this explanation is wholly ſet aſide by a circumſtance which was overlooked both by Dr. M. Wall and the gentleman he alludes to, namely, that the addition of an acid prevents the precipitate; and this ſeems to confirm the account of the precipitate given by the latter: we ſhall find, however, that it is not owing to the preſence of carbonat of ammonia, but to a cauſe which it would oblige me too much to anticipate the Analyſis I am about to lay before the reader to conſider here.

In the 24th experiment related by Dr. M. Wall, potaſs gave a precipitate with three quarters of a pint of Malvern water, boiled down to half an ounce; and in experiment 26th, a ſolution of ammonia gave a precipitate with this water, boiled down in the ſame manner; and this precipitate being removed by filtration, it became turbid in about a minute after the addition of a few drops of a ſaturated ſolution of carbonate of potaſs. From theſe experiments,

Dr. M. Wall infers that the Malvern water contains ſelenite.

This inference ſeems, on more than one account, to be inadmiſſible. Had the water contained ſelenite, it muſt have been precipitated long before the evaporation was carried to this length. Beſides, the preſence of ſome other earthy ſalt may have occaſioned this precipitate, or that with the ammonia may have been produced by carbonat of magneſia, which is not wholly precipitated by boiling till the water is evaporated nearly to dryneſs. * But this ſubject I ſhall have occaſion to reſume; the precipitate which Dr. M. Wall obtained by potaſs, after the addition of the ammonia, demands more particular attention in this place.

There can be no doubt, I think, from the following circumſtances, that this precipitate proceeded from the impurity of the ſolution of ammonia which had been employed. Unleſs this ſolution is prepared with care, it may contain a ſmall quantity of the lime used for obtaining ammonia from the muriat of ammonia. I repeated Dr. M. Wall's experiment with Malvern water evaporated to leſs than a twentieth part of its bulk, and a ſolution of ammonia which I had by me, and found the reſult as he has ſtated

* See Mr. Kirwan's Essay on the Analysis of Mineral-Waters, page 200. I have made much use of this excellent Essay, and have followed the plan of analysis recommended in it.

it,

it, a ſolution of carbonat* of potaſs giving a precipitate; but when I uſed a pure ſolution of ammonia, prepared by Mr. Accum, no precipitate took place on the addition of the ſolution of carbonat of potaſs. In the above experiment, as in Dr. M. Wall's, it was not till about a minute after the addition of the potaſs that the precipitate was fully formed.

It will be neceſſary to notice ſeveral other experiments of Dr. M. Wall, when I come to ſpeak of the ſubjects to which they relate.

What has juſt been ſaid reſpecting the ſolution of ammonia, was not neceſſary to demonſtrate how requiſite it is to have the teſts we employ in analyſis prepared with the greateſt care. All the teſts uſed in the following Analyſis, whoſe ſpecific gravity is mentioned, were prepared by Mr. Accum; the others were prepared by Meſſrs. Allen and Howard, of Lombard-ſtreet, with the exception of a few which I prepared myſelf, according to the directions given by the moſt approved writers.

On the manner in which I have employed

* All the potass of commerce is more or less carbonated: Dr. M. Wall used what is called oleum tart. per deliq.

one

one teſt, the litmus, of which I have made frequent uſe, it will be neceſſary to make ſome obſervations. It may be made a teſt of greater delicacy than it is in the ordinary way of applying it. After making various trials, I thought the following the beſt way of uſing it:

Let two cryſtal baſons of the ſame ſize, with cylindrical ſides and flat bottoms, of at leaſt four inches diameter, be placed on a ſheet of white paper, and another ſheet of white paper placed behind them, and let the obſerver ſtand between them and the quarter from which the light comes, that he may receive the light reflected from behind and below them. Let one of the baſons be filled to about one inch in height with the water in which we ſuſpect the preſence of an acid, and the ſame quantity of diſtilled water be put into the other, and to each let the ſame number of drops of a ſtrong infuſion of litmus be added; let the quantity of litmus be no more than is ſufficient to give them the ſlighteſt tinge, which ſhews decidedly the blue colour in the diſtilled water; by comparing the colour of the water in the two baſons, a very ſmall quantity of acid may be detected, eſpecially by a perſon accuſtomed to uſe the teſt in this way.

Mr. Kirwan ſays, that with paper ſtained with litmus (his mode of uſing this teſt) he could not

not diſcover $\frac{1}{12,000}$ of ſulphuric acid. By the foregoing mode of uſing the litmus, it is rendered many times more ſenſible, as will appear from the following experiment.

To two ounces of water, ſulphuric acid was added in the proportion of 1 to 307200. This was put in one of the baſons placed as above; in the other, two ounces of water, which I had previouſly found did not affect the colour of the litmus. On dropping into both baſons the ſame quantity of infuſion of litmus, the colour was ſenſibly redder in the baſon which contained the acid than in the other; the difference was ſuch as could be readily obſerved by a perſon accuſtomed to make ſuch experiments.

When I diluted the acid in the proportion of 1 to 460800, I could not obſerve the difference of the ſhade. The ſpecific gravity of the acid employed was 1,85, ſo that one grain of this acid contained 0,7946 grs. of real acid, as nearly as can be aſcertained from Mr. Kirwan's table of the ſpecific gravity of ſulphuric acid mixed with different proportions of water.*

* The specific gravity of the acid mentioned in Mr. Kirwan's table, whose specific gravity comes nearest to that I used, and a grain of which contains 0,7946 grs. of real acid, is 1,8542, so that it differs from that I employed only by 0,0042. The circumstance which renders it so difficult to ascertain the quantity of real acid in any mixture of sulphuric acid and water is, that the specific gravity does not increase in the same proportion with the quantity of real acid.

It

It appears, then, from the foregoing experiment, that 0,7946 grs. of ſulphuric acid may be detected by the litmus uſed as I propoſe in 307200 grs. of water, ſo that one grain of real ſulphuric acid may be detected by this teſt in 386597 grs. or 50,33 pints, of water.

It follows from what has been ſaid, that the litmus employed in this way may alſo be made a very delicate test of alkalis, as litmus reddened by an acid will detect the preſence of any quantity of alkali capable of neutraliſing the acid which changed its colour.

Mr. Kirwan has found 45,2 of real ſulphuric acid ſaturate 54,8 of potaſs; therefore one grain of this acid ſaturates 1,2123 grs. of potaſs; hence 1,2123 grs. of potaſs may be detected by the litmus in 386597 grs. of water, that is, 1 grain in 318895 grs. or 41,52 pints, of water.

The ſame chemiſt has found that 56 grs. of real ſulphuric acid ſaturate 44 grs. of ſoda, therefore a grain of this acid ſaturates 0,7857 grs. of ſoda; hence 0,7857 grs. of ſoda may be detected by the litmus in 386597 grs. of water, that is, one grain of ſoda may be detected in 492041 grs. or 64,06 pints, of water.

He has alſo found that 54,66 grs. of real ſulphuric acid ſaturate 14,24 grs. of ammonia; therefore a grain of this acid ſaturates 0,2605 grs. of ammonia; hence 0,2605 grs, of

of ammonia may be detected by the litmus in 386597 grs. of water, that is, 1 grain of ammonia may be detected in 1484057 grs. or 193,23 pints, of water.*

The litmus ufed in this way is a much more fenfible teft of alkalis than the moft delicate teft of them mentioned by Mr. Kirwan, namely, paper ftained with Brazil wood, which detects one grain of carbonat of foda in 9945 grs. or 1,16 pints, of water.

To determine whether the colour of the litmus is reftored by fixed alkalis or carbonated earths, we muft have recourfe to the method employed by Mr. Kirwan for this purpofe, in the ufe of the teft juft mentioned, evaporating the water to one half of its bulk, which will increafe the effect of the litmus, if it arifes from a fixed alkali, but diminifh or wholly prevent it, if from carbonated earths.

If the prefence of ammonia be fufpected, the teft muft of courfe be applied to the firft part of the water which rifes in diftillation.

To afcertain by the litmus the quantity of carbonat of alkali which exifts in water, I have found the following method the moft convenient:—Into one of the bafons placed as

* Other writers make the foregoing proportions different, but Mr. Kirwan's known accuracy has induced me to adopt his.—When we know the quantity of alkali, it is easy to ascertain what its quantity would be if carbonated, the state in which it always exists in mineral waters.

above

above put a certain quantity of acid, 0,001 grs. for example, to equal quantities of the water to be analysed and of distilled water add an equal quantity of a strong infusion of litmus; let the former of these be put by small quantities at a time into the bason containing the acid, and the latter by equal quantities into the other bason, till the shade of colour in the two basons is exactly alike; then the nature of the alkali having been previously ascertained, the quantity of water required to saturate the known quantity of acid will, by the above proportions, give the quantity of alkali it contains.

The filtering paper used in the following experiments was white paper deprived of its glue, by Mr. Accum.

AN ANALYSIS, &c.

CHAP. I.

OF THE HOLY-WELL WATER.

IN the following Analyſis of the Malvern waters I ſhall begin with the water of the Holy-well, becauſe it contains a greater quantity of foreign ingredients than that of St. Ann's.

Sect. 1.

Of the Gaſeous contents of the Holy-well water.

From the following experiments, Dr. Martin Wall concludes that the Holy-well water contains carbonic gas:

" Experiment 1. To a glaſs of the water at " the ſpring head a ſmall quantity of lime water " was added: ſmall diſtinct flocculi formed, and " floated throughout, but not numerous.

" Exper. 2.

" Exper. 2. A half pint bottle, containing
" about $\frac{3}{4}$ of an ounce of clean iron filings,
" was filled at the ſpring head with the water,
" ſealed up and carried to Worceſter: the next
" morning ſome of the water was poured into a
" glaſs without filtering it, and upon the ad-
" dition of ſome infuſion of galls the whole
" preſently became of a fine purple colour,
" which it retained ſome time without turning
" black.

" Exper. 3. A part of the remainder of the
" water employed in experiment 2 was filtered;
" and, upon adding ſome infuſion of galls, no
" change of colour enſued but that which re-
" ſulted from the dilution of the colour of the
" infuſion; no purple tinge or ſhade in the
" ſmalleſt degree.

" Exper. 5. A phial, containing about half
" an ounce of clean iron filings, was filled with
" Malvern water at the ſpring, ſealed up, and
" in about ten days it was brought to me at
" Oxford, where it was kept near a week longer.
" The cork when drawn came out with violence
" and noiſe, as it uſually does from the bottles
" of Pyrmont and Spa waters; and this violence
" was attended with a chalybeate ſmell. A ſmall
" quantity of this water was decanted carefully
" through a piece of linen cloth into a glaſs:
" the water thus filtered was not clear, it had a
" ſlight chalybeate taſte; and upon adding to it

" ſome

" ſome drops of infuſion of galls, it aſſumed a
" muddy purpliſh hue, which colour gradually
" ſubſided to the bottom, and the water above
" became clear.

" Exper. 6. I filtered the remainder of the
" water uſed in experiment 5 through thin
" paper, it had a very ſlight flavour, and
" ſtill ſlighter taſte, of iron; it gave no purple
" or black colour on the addition of infuſion of
" galls, but only diluted the yellow colour of
" the infuſion.

" It ſhould be remarked that before the phial
" of water uſed in experiments 5 and 6 was
" opened, it was obvious that a part of the fil-
" ings had ſuffered a conſiderable corroſion, and
" perhaps a partial ſolution: the lower part con-
" tinued perfectly in a metallic ſtate, but over
" it floated a light black powder, which was
" nearly in the proportion of one fifth of the
" whole."

1. On repeating the firſt experiment of Dr. M. Wall, I found the reſult as he has ſtated it. Lime water was mixed with Holy-well water in equal quantities at the ſpring; although the tranſparency was not at firſt diſturbed, in a ſhort time they became ſlightly turbid, and ſmall flocculi were ſeen floating in the water.

2. Strontian water was mixed with it in equal quantities, at the ſpring. The turbidneſs now

appeared fooner, and increafed to fuch a degree as to give a milky appearance to the water.

3. Barytic water was mixed with it in equal quantities at the fpring. The turbidnefs now appeared ftill fooner, and the milky appearance of the water became more confiderable.

Thefe are precifely the effects which a fmall quantity of carbonic gas diffolved in water produces, but none of them are decifive of its prefence, for many other fubftances found in mineral waters will give the fame appearances with all thefe tefts.

Barytes, Strontian and lime have a ftronger affinity for carbonic acid than any of the alkalis, magnefia, alumina, or iron; and, confequently, when the carbonats of any of thefe exift in mineral waters, Barytes, Strontian and lime will attract the carbonic acid from them. I have found that Barytic and Strontian water occafion a very evident turbidnefs in water which contains carbonat of Soda in the proportion of 1 grain to 45,000 grs. or near fix pints.

Befides thefe carbonats, the foregoing tefts (as Mr. Kirwan obferves) give precipitates with various earthy falts, and the mere effect of carbonic gas is not eafily diftinguifhed. Barytic water alfo gives a precipitate with fulphats.

Nor are the experiments with iron filings decifive of the prefence of carbonic gas. Although it

it be found that the Holy-well water becomes more impregnated with iron than pure water, under the fame circumftances, would be, it does not follow that it contains carbonic gas; other fubftances found in mineral waters are capable of diffolving iron.

4. I repeated Dr. M. Wall's experiment. A fix ounce bottle, containing above half an ounce of iron filings, was filled at the fpring head with Holy-well water, clofely corked and fealed. After it had ftood above forty-eight hours, it was opened, and fome of the water poured out, which gave a purple colour on adding to it a few drops of tincture of galls, but this colour neither difappeared on filtering the water, nor did it fubfide with the filings. A little of this water was expofed to the air for more than twenty-four hours; at the end of this time the purple colour was as ftrong as at firft.

5. Some Holy-well water was kept expofed to the air for feveral weeks. It was then mixed with iron filings, allowed to remain expofed to the air, and in about twelve hours filtered. On adding to it a few drops of tincture of galls, it became of a dark purple.

But any water will give the foregoing appearances with iron filings; I have repeated them with diftilled water, and found the refults the fame.

Nor is it difficult to account for the cork of the

the bottle, in which the iron and water had been kept, coming out with noiſe, which alſo happened in my repetition of Dr. M. Wall's experiment.

The black powder which floated over the iron filings is an oxid of iron, which may be formed by allowing iron to lie in any water in the temperature of our ſummer, and is produced by the decompoſition of the water. Its oxigen combines with the iron forming the black powder, while the hydrogen is diſengaged in the form of gas: and from this gas it ariſes that the cork comes out with noiſe. When conſiderable heat is applied to water and iron filings, the hydrogen gas is ſeen to riſe in bubbles from the iron, and may be collected; the iron, at the ſame time, from which it riſes, being converted into the black powder mentioned by Dr. M. Wall. In making the experiment, indeed, in the common temperature of our ſummer, if the veſſel is allowed to remain at reſt for ſome time, on ſhaking it, a great number of air bubbles riſe from the filings. More bubbles are formed on again allowing the veſſel to remain at reſt, and ſo on, till all the iron is oxidated.

Mr. Kirwan regards the litmus as the only teſt by which we can aſcertain the preſence of the carbonic gas in waters. "Waters," he obſerves, "that contain uncombined fixed air to "the amount of $\frac{1}{16}$ of their bulk, or partly com-

"bined,

" bined, partly femi-combined and partly un-
" combined, fo that the uncombined part
" amounts to $\frac{1}{15}$ or more of their bulk, will red-
" den infufion of litmus.

" To render this teft decifive," he obferves, a little lower, " it is neceffary, 1ft. That the " rednefs be fugacious, and capable of repeated " renovation and evanefcence by frefh additions " of the mineral water, which diftinguifhes " this air from very dilute folutions of the mi- " neral acids; for thefe alfo may excite an eva- " nefcent rednefs for fome time, that is, until " the alkali contained in the litmus is faturated, " as Bergman has well obferved. 2d. That the " mineral water fhould give a precipitate with " lime water foluble in the mineral acids with " effervefcence: this diftinguifhes fixed air from " hepatic air, which alfo fugacioufly reddens " infufion of litmus."

6. To the water at the fpring, a few drops of a ftrong infufion of litmus was added fo as to give the whole a flight tinge. The litmus was not at all reddened. It had exactly the fame appearance as if the infufion had been dropped into diftilled water.

Even the litmus, however, cannot be regarded as a decifive teft of the prefence of carbonic gas, for as the above-mentioned tefts often feem to indicate the prefence of this gas where it does not exift, the litmus fometimes fails to indicate

indicate its prefence even where the quantity is great; for I have found that however much the infufion of litmus is reddened by charging it with carbonic gas, its colour is immediately reftored by adding to it a fmall quantity of any of the alkaline carbonats, although they have been perfectly faturated with the carbonic acid. Waters containing fuch carbonats, therefore, may contain carbonic gas, although they do not redden the infufion of litmus.

It appears then, that we have no teft which will in all cafes afcertain the prefence of carbonic gas in water; this can only be done, therefore, by feparating, by means of a mercurial apparatus, the gafeous contents of the water, and examining their properties when they can no longer be affected by its other contents.

7. Into a glafs veffel, connected by means of a glafs tube, with fuch an apparatus, eight ounces of the Holy-well water were put at the fpring, the whole contents of the veffel and tube being twelve ounces and three drams. The water was gradually heated, and made to boil for a quarter of an hour, and the air which came over, received in a glafs jar graduated to the cubic inch, inverted over the mercury. In order to eftimate any lofs of air which might take place in the experiment, the fire was removed, that the apparatus might return to the temperature of the air, and the fpace which the air

air in the jar occupied, the height of the mercury of the jar above that of the trough, and the height of the barometer and thermometer were noted. Half an ounce of a ftrong folution of potafs, which had been wholly deprived of its carbonic acid by being boiled with lime, was then thrown into the jar; but, although it was ftrongly agitated with the air in the jar for a confiderable length of time, no abforption whatever took place, the furface of the folution of potafs remaining exactly at the fame point of the fcale, attached to the jar, as on its firft introduction.

A condenfation of the air in the jar neceffarily takes place on the introduction of the folution, in confequence of the defcent of the mercury, fo that the point of the fcale occupied by the furface of the folution is higher than that which the furface of the mercury had occupied.

This condenfation is eafily diftinguifhed from any abforption of the air, becaufe it is proportioned to the increafe of atmofpherical preffure from the defcent of the mercury, and completed at the moment the folution of potafs is introduced.

The jar and its contents were then removed into a tub of water, and a quantity of nitrous gas, under the fame atmofpherical preffure equal in volume to the air which the jar contained, in-

 troduced

troduced into it. The nitrous acid was immediately formed, and, on agitation, the water rofe to the fame point of the fcale it occupied before the introduction of the nitrous gas. The whole of the air contained in the jar, therefore, was atmofpherical air.

The Holy-well water, then, contains no carbonic gas. The precipitate occafioned by the Barytic, Strontian and lime water confequently arofe from fome other part of its contents.

Sect 2.

Of the Carbonats contained in the water of the Holy-Well.

8. A dilute infufion of litmus, prepared with filtered rain water, was fenfibly reddened by a very fmall quantity of acetous acid. It was then divided into two equal parts ; to the one was added a certain quantity of filtered rain water; to the other the fame quantity of the water of the Holy-well, which had been kept feveral days in a bottle, flightly corked. The latter appeared of a bluer colour than the other. The fame quantity of filtered rain water was again added to the firft, and of Holy-well water to the other: the difference of colour was then more confiderable. This experiment was feveral times repeated with the fame refult.

9. Into filtered rain water, and Holy-well water at the fpring head, a little of an infufion

of litmus, reddened by an acid, was dropped. The Holy-well water ſoon aſſumed a bluer colour. Both in this, and the former experiment, I thought the difference of colour continued to become more conſiderable for ſeveral hours, during which I occaſionally obſerved it.

10. Thirty-two ounces of Holy-well water were ſlowly evaporated to two ounces and a half, with a ſand heat, in a glaſs retort and receiver, put together without luting. When about one half of the water had paſſed over into the receiver, that in the retort had aſſumed a milky appearance, which gradually increaſed, and a white powder was at length depoſited, part of which ſubſided very ſlowly. This powder was ſeparated by filtering the water, and ſubjected to the action of diluted muriatic acid. A conſiderable effervefcence took place.

The acid was then ſeparated from the part of the powder which it had not diſſolved by filtering; and to this acid a few drops of ſulphuric acid (ſp. gr. 1,85) were added, without occaſioning any precipitate or turbidneſs. A few drops of alcohol (ſp. gr. 0,817) were then added, and the temperature raiſed to above 130° of Farenheit. It was then ſet apart for twenty-four hours. At the end of this time a conſiderable depoſition of ſelenite was formed. This experiment was repeated ſeveral times with the ſame reſult. From which it appears

that

that the powder which occaſions the milkineſs in this water, when part of it is evaporated, contains carbonat of lime.

11. The firſt part of the foregoing experiment was repeated; but inſtead of adding to the filtered acid ſulphuric acid and alcohol, a little of a ſolution of ammonia (ſp. gr. 1,26) was dropped into it: a cloud appeared, which was gradually formed into a light white precipitate,* lying near the bottom of the veſſel. It appears, from this experiment, that the milky appearance of the water is partly owing to the preſence of magneſia.

12. On examining the retorts in which the foregoing diſtillations were performed, the part which had contained the water was found lined with a thin film. A ſmall quantity of diluted muriatic acid was poured into them. Wherever the acid touched the film, an efferveſcence enſued. The acid was then filtered. It gave no precipitate with oxalic acid; but, on adding to it the ſame ſulphuric acid uſed above, (9.) a precipitate was immediately formed, which was much increaſed on the addition of a few drops of alcohol.

It

* See Mr. Kirwan's Treatise on the Analysis of Mineral Waters, p. 93 and 94. When the water is agitated before it is poured out of the retort, so as to bring away with it the powder which has fallen to the bottom, this precipitate is of a brownish colour; for the cause of which see Exper. 15th.

It ſeems, at firſt ſight, difficult to reconcile theſe appearances, as the oxalic acid is a more delicate teſt of lime than the ſulphuric; they are readily explained, however, when we know that the preſence of a mineral acid will prevent the appearance of a precipitate from the oxalic acid notwithſtanding the preſence of lime. "Where the mineral acids abound," Mr. Kirwan obſerves in a Treatiſe above referred to,* "and are in ſome meaſure diſengaged from "any combination, they either decompoſe the "ſaccharine acid or diſſolve the ſaccharated "lime, if any be formed, and thus prevent, "either totally or partially, the appearance of "a precipitate, as I have long ſince obſerved in "analyſing ſtones."

13. To another portion of the diluted acid uſed in the laſt experiment, to whoſe action the film in the retort had been ſubjected, a few drops of the ſame ſolution of ammonia uſed above (11.) were added; a browniſh white fleecy precipitate enſued. The film formed on the retort, then, as well as the powder obtained by filtering, contains both carbonat of lime and carbonat of magneſia.

14. In order to aſcertain whether the Holy-well water contains iron, a correſpondent of Dr. M. Wall added to it at the ſpring ſome infuſion of galls, and obſerved no change of colour.

He

* Page 88.

He then evaporated a pint and a half to three ounces, and found no change of colour on adding to it infufion of galls.

Thefe experiments I have repeated with the tincture of galls with the fame refult. The Holy-well water, evaporated to lefs than a 70th part of its bulk, gave no colour either with tincture of galls or pruffiat of potafs.

Water may contain iron, however, which will elude thefe means of detecting it. If it contains carbonat of iron in too fmall quantity to be detected by the tefts at the fpring, we fhall not detect it in the water evaporated to however fmall a quantity, becaufe the carbonat of iron will be depofited during the evaporation.

15. To afcertain whether the Holy-well water contains any carbonat of iron, a gallon was flowly evaporated to two ounces and a half in a glafs retort and receiver, luted together. It was then filtered, and the powder which remained in the filter fubjected to the action of diluted muriatic acid. The cruft, which adhered to the retort, was alfo fubjected to the action of the fame acid. Both thefe portions of acid were found to contain iron. By the following procefs any teft of iron will readily detect it. Both acids we have feen contain lime. This was feparated as in Exper. 10, a precipitate fimilar to that juft defcribed (13.) was then obtained by a folution of Soda, and allowed to fubfide, and as much

much of the fluid poured off as could be done without difturbing the precipitate: enough of diluted muriatic acid was added to re-diffolve the precipitate. It then gave a deep purple, with tincture of galls; and a copious blue precipitate, with pruffiat of potafs.* This experiment may be made without feparating the lime, which is a tedious procefs, if ammonia be ufed inftead of Soda; as by the former, the iron may be precipitated, mixed with only a fmall quantity of magnefia.

The foregoing fubftances, namely, the lime, magnefia and iron, form the whole of what is taken up by the diluted muriatic acid from the precipitate obtained by evaporating the Holywell water, whether the powder which is found in the remaining water, or the film which adheres to the retort, is fubjected to its action; for thefe are of the fame nature.

A refiduum is left after the action of the acid, on which I fhall foon have occafion to make fome obfervations: we are now to examine

* If prussiat of potass is added to this fluid, as long as any blue precipitate is formed, and this precipitate is separated by filtering, the magnesia alone may then be precipitated by a solution of ammonia. This experiment I have frequently made: when the magnesia is precipitated as above (13.) it is necessarily mixed with the iron. The peculiar appearance of the precipitate sufficiently indicates its presence. It is to be recollected, that the acid contains no other substance which can be precipitated by ammonia but iron and magnesia.

mine the water left in the retort after the diſtillation.

16. A gallon of Holy-well water was evaporated in a glaſs retort and receiver, luted together, to two ounces and a half; to which, after it was filtered, a little of a ſtrong ſolution of ammonia was added. After it had ſtood for ſeveral hours, the bottom of the veſſel was covered with a ſmall quantity of a white powder, which, after it had remained for ſome time expoſed to the air, effervefced with acids. The reſult of this experiment might have been foreſeen, from what has already been ſaid, as magneſia is not wholly depoſited by ebullition till the water is evaporated nearly to dryneſs.

17. A gallon and a half of Holy-well water were ſlowly evaporated to fifteen ounces in a glaſs retort and receiver, luted together. The water remaining in the retort was then filtered, and paper ſtained with turmeric was dipped into it. In leſs than a minute, without the aſſiſtance of heat, the paper was changed to a reddiſh brown. From this experiment it appears that the Holy-well water contains a carbonat of fixed alkali; for, according to Mr. Kirwan, the only other ſubſtances which could produce this effect are pure alkalis, lime and carbonat of ammonia. The firſt never exiſts in mineral waters. If carbonat of ammonia exiſts in the Holy-well water,

it

it muſt come over into the receiver during diſtillation. If the effect on the turmeric paper had proceeded from lime, a pellicle would have been formed on the ſurface of the water remaining in the retort by expoſure to air, which was not the caſe. Uncombined lime, indeed, is very rarely found in mineral waters; and Bergman ſays, it muſt be in hot, not in cold mineral waters, that it exiſts.

18. The preſence of a carbonat of fixed alkali in the Holy-well water may be aſcertained in another way, equally ſimple, which at the ſame time proves that it is chiefly owing to it that this water poſſeſſes the power of neutraliſing acids. This power muſt ariſe from the preſence of carbonats of ſome of the earths, or of carbonat of ammonia, or of carbonat of a fixed alkali. If it ariſes from any of the earthy carbonats, except the carbonat of magneſia, or from carbonat of ammonia, ebullition will wholly deſtroy it. If from carbonat of magneſia, ebullition, if it increaſes it at all, will increaſe it only in a ſlight degree. It will ſoon arrive at its maximum; and beyond this, however much the water is evaporated, it will be impoſſible to increaſe its power of neutraliſing acids.

If this power ariſes from the preſence of a carbonat of fixed alkali, it will be increaſed by evaporation nearly as long as any of the water remains. This is found to be the caſe with the Holy-well

water. Evaporating part of the water increafes its power of neutralifing acids; and however far the evaporation is carried, by carrying it farther, this power is ftill increafed.

The exiftence of a carbonat of fixed alkali in this water accounts for many obfervations which have been made refpecting it. It is remarked, that clothes may be wafhed in it with lefs foap than in any other; and that veffels, which are incrufted by hard water having been boiled in them, are cleaned by boiling in them the Holy-well water.

"Upon the whole," Dr. J. Wall obferves,*
"too much care cannot be taken by thofe who
"fend for this water from the well that their
"bottles be perfectly clean; fince it is known
"that this water will diffolve thofe foulneffes
"which common water will not touch.

"Waters, full of earthy particles, are found
"to foul and incruft the veffels in which they
"are boiled; as is evident in tea-kettles,
"&c. which veffels may again be perfectly
"cleaned by boiling fome of thefe pure waters
"in them."

But the effect of the pureft water in removing this cruft will not be found equal to that of the Holy-well water, and indeed is very trifling, the cruft formed being fulphat of lime, which is very

* See his Tracts, p. 117.

very infoluble in water, but is readily decompofed by all the alkaline carbonats.

The prefence of the alkaline and other carbonats readily accounts for the precipitate obtained by Barytic, Strontian and lime water.

19. Thirty ounces of Holy-well water were flowly evaporated to lefs than a dram, care being taken to prevent any of the alkaline carbonat from remaining on the fides of the veffel in which the evaporation was performed; a folution of tartareous acid (fp. gr. 1,56) was then added freely, but no depofition of fupertartrite of potafs enfued; it was then flowly evaporated to drynefs, but no fupertartrite of potafs was formed. The alkaline carbonat which this water contains, therefore, is the carbonat of Soda.

20. In my firft diftillations of the Holy-well water, the water which paffed over into the receiver ftill gave precipitates with acetat of lead and nitrat of filver, both of which were prevented by the previous addition of an acid to the diftilled water. It feemed a fair inference from thefe circumftances, and indeed Mr. Kirwan, in his Treatife on the Analyfis of Mineral Waters confiders it as fuch, that the water contains carbonat of ammonia. This opinion, however, feemed improbable, becaufe the precipitates given by the firft part of the water which came over were lefs copious than thofe given by the water previous to diftillation.

It

It was wholly ſet aſide by its being found, in the above diſtillations, that the water which came over firſt did not give more copious precipitates than that which came over towards the end of the diſtillation.

I could only explain the appearance of theſe precipitates by ſuppoſing that a ſmall part of the carbonat of Soda had paſſed over with the water, from the diſtillation having been conducted too rapidly, although it had been performed in a very large retort, whoſe contents were many gallons, and in which I put only a gallon or a gallon and a half.

21. To aſcertain the truth of this opinion, a gallon of Holy-well water was diſtilled to a few ounces in a glaſs retort and receiver, with a heat below the boiling temperature. The water which came over gave no precipitate either with acetat of lead or nitrat of ſilver.

22. A ſmall quantity of carbonat of Soda was diſſolved in filtered rain water, which, I had previouſly found, gave no precipitate with either of the foregoing teſts. It was diſtilled in a glaſs retort and receiver, in a heat which made it boil pretty briſkly. The water which came over gave a precipitate with both acetat of lead and nitrat of ſilver.

23. But the carbonat of Soda is not the only part of the ſolid contents of the Holy-well water which comes over if the diſtillation be rapid.

I three

I three times diſtilled a quart of this water in the ſame retort and receiver, with different degrees of heat, and found that the powder obtained by filtering the water which remained in the retort, was leſs in proportion as the diſtillation had been more rapid. It is on this account that, in the diſtillations I ſhall afterwards have occaſion to mention, for the purpoſe of aſcertaining the quantities of the different carbonats, the water was not permitted to boil.

24. It is mentioned above (15.) that a reſiduum is left after the action of the diluted marine acid on the precipitate obtained by diſtillation. This reſiduum remains unchanged in the following fluids, although the temperature is gradually increaſed till they boil: ſulphuric acid (ſp. gr. 1,85), muriatic acid (ſp. gr. 1,12), nitric acid (ſp. gr. 1,146), fluoric acid (ſp. gr. 1,42), ſtrong ſolutions of all the alkaline carbonats, a ſolution of ammonia (ſp. gr. 1,26), alcohol (ſp. gr. 817).

25. By a ſtrong ſolution of potaſs or Soda it is completely diſſolved in the common temperature of the air, and very rapidly, if heat is applied.

The fluoric acid ſeems to act partially on the reſiduum; but this appearance is deceitful, and proceeds from a circumſtance which it will be neceſſary to explain at length.

In diſtilling the Holy-well water in glaſs veſſels, an appearance takes place which I was

at

at firſt at a loſs to account for. After the diſtillation has continued for ſome time, a number of ſhining particles appear in the water remaining in the retort which ſparkle in the ſunſhine. The agitation of the water in boiling ſeems neceſſary to their appearance, for when the diſtillation is conducted very gently, none of them are found in the water: but after gently pouring out the Malvern water, if any water be ſtrongly agitated in the retort, it is found to contain them; and if the preceding diſtillation has been long continued, generally in very great quantity. I found that they were inſoluble in the ſulphuric, muriatic and nitrous acids, alſo in ſolutions of the alkaline carbonats; but with the aſſiſtance of heat, readily ſoluble in ſolutions of potaſs or Soda. Theſe circumſtances rendered it probable that they were ſilicious, which, together with their brilliancy, ſuggeſted the idea of their being fine laminæ ſeparated from the ſurface of the glaſs. This induced me to boil the Holy well water in an iron veſſel, but however long the boiling was continued, none of the ſhining particles appeared. When I found that this water contains a carbonat of Soda, it did not ſeem improbable that, by long boiling, the carbonat, from the affinity of the Soda to glaſs, might ſo looſen the ſurface of the glaſs that, by the agitation of boiling, ſmall laminæ might be detached from it. This ſeemed the

more

more probable, as glaſs is eaſily diſſolved by boiling ſolutions of pure potaſs or Soda. I have myſelf ſeen the bottom of a glaſs retort deeply eroded by boiling them in it for a few hours: and it may be obſerved, that, in this inſtance, the ſhining particles appeared in the alkaline ſolution. Dr. Prieſtly has ſhewn indeed that boiling water itſelf, if long applied, will diſſolve glaſs. In order to aſcertain this point, I repeatedly boiled in a florence flaſk, for ſome hours, a weak ſolution of carbonat of Soda, and found that the ſame ſhining particles made their appearance. The ſurface of the glaſs ſeems to be that which is moſt eaſily detached; for I found that when a ſolution of Soda was repeatedly boiled in the ſame flaſk, the ſhining particles, at length, either ceaſed to appear or appeared in ſmall quantity: but if the flaſk was ſo placed that the fluid touched a freſh ſurface, they then made their appearance as at firſt.

This appearance ſeems conſtantly to attend the ſolution of glaſs in a boiling fluid. I have juſt remarked, that it takes place when a ſolution of potaſs or Soda is boiled in it. I have found that boiling the fluoric acid in a glaſs veſſel produces the ſame effect. The ſurface of the glaſs ſeems looſened by the ſolvent, and broken off by the agitation of boiling. As theſe ſhining particles remain in the filtering paper with the

reſiduum,

refiduum, they account for the apparent action of the fluoric acid.

Sect. 3.

Of the Saline contents of the water of the Holy-well.

The only acids, if we except the carbonic gas, which have been found to exift in mineral waters, are the fulphureous, fulphuric, muriatic, nitric and boracic acids.

Of thefe the fulphuric, muriatic and nitric acids have never been found uncombined in thefe waters. The fulphuric acid has been found femicombined. The fulphureous and boracic acids have been found uncombined; they do not, however, exift in this ftate in the Holy-well water, as appears from the experiments which have been related.

Neither the fulphureous nor boracic acid have been found in a combined ftate in mineral waters. Mr. Kirwan thinks the former probably exifts in this ftate in fome of the hot fulphureous waters. Of the latter he obferves, "the boracic acid, uncombined with any bafis "has been found in fome lakes in Italy. 16 "Roz. Journ. and 2 Mem. Dijon, 1784, p. 151. "In a combined ftate with natron it probably "exifts in thofe lakes of Thebet and Perfia, "where tinckal is found; perhaps, alfo in Hungary, where lakes abounding in natron occur, and

" and where it does not appear to have been
" fought for.*

The only acids, therefore, which we are to look for in the Holy-well water, are the ſulphuric, muriatic and nitric acids, in a ſtate of combination.

25. A few drops of a ſolution of nitrat of Barytes was added to the Holy-well water at the ſpring. No precipitate nor cloud enſued.

26. Thirty ounces of this water were evaporated to two ounces; to which, more acetous acid than was neceſſary to ſaturate the baſis of the alkaline carbonat it contains, was added. A ſolution of acetat of Barytes was then dropped into it; a white precipitate immediately enſued.

From theſe experiments it appears that the Holy-well water contains ſulphuric acid, but not in conſiderable quantity.

27. More nitrous acid was added to ſome Holy-well water than was ſufficient to ſaturate the baſes of the carbonats it contains, and without any previous diſtillation a ſolution of nitrat of ſilver was dropped into it; a cloud immediately appeared. This water, therefore, contains muriatic acid.

28. The muriatic acid may eaſily be obtained from it in a diſengaged ſtate. The water was boiled till the earthy carbonats were precipitated; it

* Mr. Kirwan's Treatise on the Analysis of Mineral Waters, p. 14.

it was then filtered and evaporated to dryneſs. A white cruſt remained, which decrepitated with heat, and efferveſced with ſulphuric acid, the muriatic acid being diſengaged in the form of gas.

29. A gallon and a half of this water were evaporated in a glaſs retort and receiver, luted together, to fifteen ounces. Part of the water which remained in the retort was deprived of its ſulphuric acid by dropping into it a ſolution of acetat of Barytes, and of its muriatic acid by dropping into it a ſolution of acetat of ſilver, as long as any precipitate could be obtained, and filtering it. It now contained only acetats and nitrats, if any exiſt in the Holy-well water. It was then evaporated to dryneſs, and the acetats diſſolved by treating them with alcohol.* No nitric acid was diſengaged on treating the reſiduum with ſtrong ſulphuric acid. This water, therefore, contains no nitric acid.

It appears, then, from all that has been ſaid, that the Holy-well water contains the carbonats of Soda, lime, magneſia and iron, and the ſulphuric and muriatic acids in a combined ſtate. It remains to be aſcertained with what ſubſtances theſe acids are combined.

In order to abridge the labour of analyſing mineral waters, Mr. Kirwan gives a table of incom-

* See Mr. Kirwan's Treatise on the Analysis, &c. p. 128.

incompatible ſalts. Under the firſt head he mentions alkaline carbonats as incompatible with earthy or metallic ſulphats, muriats or nitrats. To this, however, there is one exception, for he gives three inſtances in which ſmall quantities of ſulphat of lime were found in the ſame water with alkaline carbonats.

I found that the powder obtained in the diſtillation juſt mentioned, in which a gallon and a half was evaporated to fifteen ounces, contained no ſulphat of lime.* This, however, is not a fair experiment, as the quantity of carbonat of Soda in a given portion of the water was ſo increaſed by the evaporation that, if ſulphat of lime does exiſt in the Holy-well water, it muſt have been decompoſed in this experiment: nor can the experiment be performed in this way ſatisfactorily; for it is neceſſary to evaporate a great part of the Holy-well water before a ſufficient quantity of the ſediment can be procured. I therefore performed the experiment in the following manner.

30. Three pints of it were boiled in a glaſs retort till ſome degree of turbidneſs appeared: it was then filtered, returned to the retort, and evaporated to about five ounces, which was found

* After it had been treated with diluted muriatic acid, it was boiled with a strong solution of carbonat of Soda, and then again subjected to the action of muriatic acid, after being washed to free it from the carbonat of Soda; no effervescence ensued.

found to give as copious a precipitate, with a ſolution of nitrat of Barytes, as if it had not been filtered. This experiment proves that the alkali acquires no ſulphuric acid during evaporation from that part of the contents of the water which is firſt precipitated by boiling, and conſequently that the Holy-well water contains no ſulphat of lime.

It appears from what has been ſaid, that the ſulphuric and muriatic acids found in this water muſt be combined with an alkali.

31. Three pints of it were evaporated to about five ounces and a half, in a glaſs retort and receiver, to which ſome lime was added, and to the firſt dram of water which came over after the addition of the lime, a few drops of a ſolution of acetat of lead were added, without occaſioning any cloud or precipitate. The alkali with which the foregoing acids are combined, therefore, is a fixed alkali.

32. Sixty ounces of this water were ſlowly evaporated, in a glaſs retort and receiver, to four ounces, which were filtered; and the carbonat of Soda was decompoſed and the Soda ſaturated with acetous acid. A ſolution of acetat of Barytes was then added as long as any precipitate appeared. After being allowed to ſtand for ſome hours, the water was again filtered to ſeparate this precipitate, and evaporated in a temperature below the boiling point

point to a dram and a half. A ſolution of tartareous acid (ſp. gr. 1,56) was then freely added; a depoſition of tartrite of Barytes immediately enſued, in conſequence of the water containing ſome acetat of Barytes; but no ſupertartrite of potaſs was formed. The water was then ſlowly evaporated to dryneſs, without the appearance of any ſupertartrite of potaſs. The ſulphat therefore is not ſulphat of potaſs.

33. Thirty ounces of this water were ſlowly evaporated, in a glaſs retort and receiver, to two ounces, and filtered. The carbonat of Soda, as in the laſt experiment, was then decompoſed, and the Soda ſaturated with acetous acid. A ſolution of acetat of ſilver was then dropped into it, as long as any precipitate appeared; and after being allowed to ſtand for ſome hours, it was filtered, and evaporated in a temperature below the boiling point to leſs than a dram. The ſame ſolution of tartareous acid uſed in the laſt experiment was then freely added to it: no ſupertartrite of potaſs appeared. It was then ſlowly evaporated to dryneſs, without any ſupertartrite of potaſs being formed. The muriat, therefore, is not muriat of potaſs.

It follows, from theſe experiments, that the ſulphuric and muriatic acids found in the Holy-well water are combined with Soda.

The

The contents of the water remaining in the retort after partial diſtillation, then, are ſulphat, muriat and carbonat of Soda.

It appears from all that has been ſaid, that the contents of the Holy-well water are the carbonats of Soda, lime, magneſia and iron; the ſulphat and muriat of Soda, and the reſiduum above mentioned (24.)

Sect. 4.

Of the quantity of Carbonats contained in the water of the Holy-well.

To aſcertain the quantity of the alkaline carbonats in mineral waters, Mr. Kirwan adviſes that the alkali ſhould be ſaturated by diluted ſulphuric acid, whoſe proportion of real acid is known from its ſpecific gravity, the quantity required being noted. This method, however, cannot be employed in the analyſis of ſuch waters as that of the Holy-well, becauſe it contains other ſubſtances capable of neutralizing acids. To enable us to draw any concluſion from ſuch an experiment in the caſe before us, all the carbonats, except that of Soda, muſt be ſeparated from the water; and this difficulty, we ſhall find, is the cauſe of another, which it does not ſeem eaſy to ſurmount.

34. Various quantities of Holy-well water, from a quart to a gallon, were evaporated with

a gentle

a gentle heat, in glafs retorts and receivers, to a fifteenth or twentieth part of their bulk; they were then filtered, and a ftrong folution of ammonia being dropped into them, they were allowed to remain at reft from twelve to twenty-four hours: at the end of this time they were again filtered. By thefe proceffes they were deprived of all their carbonats, except the carbonat of Soda. They were then boiled for a fufficient length of time to expel the ammonia.

To afcertain what quantity of carbonat of Soda they contained, diluted fulphuric acid, whofe quantity of real acid had been afcertained, was added to them, the litmus being ufed as the teft of faturation; but the refults of no two of thefe experiments correfponded, and all of them indicated lefs carbonat of Soda than, from other experiments, I had reafon to believe the water contained. That I might avoid every caufe of error, I performed the diftillations very flowly, fome of them without permitting the water to boil; retorts were ufed which had never been employed for any other purpofe, and which were repeatedly wafhed with the Holy-well water, and the filtering paper was that mentioned in the Introduction.

With all thefe precautions, I could arrive at no conclufion refpecting the quantity of the alkaline carbonat. The greater the quantity of water, and confequently the larger the veffels employ-

ed,

ed, the more diſſimilar, in general, was the reſult. Theſe circumſtances can only be attributed to the carbonat having met with more or leſs acid, notwithſtanding the precautions employed, in the tedious proceſs it underwent to prepare it for the ſulphuric acid. And although this acid would diſplace that which the Soda had attracted, the diſplaced acid would equally with the ſulphuric affect the litmus. I found, indeed, that even handling the filtering paper was capable, owing to the acid which eſcapes by inſenſible perſpiration, of influencing the reſult of this experiment. After devoting much time to it, I was convinced that no certain concluſion reſpecting the quantity of the carbonat of Soda could be drawn from it. I therefore had recourſe to another method, which may be regarded as deciſive, becauſe, in repeating it, the reſults were found to correſpond.

35. Half a grain of carbonat of Soda was diſſolved in twelve ounces of diſtilled water, which were heated to 136°. Paper ſtained with turmeric was allowed to remain in it for one minute at this temperature. It was not at all reddened. This water was gradually evaporated at a temperature never exceeding 140°. and at ſhort intervals ſlips of paper ſtained with turmeric were dipped into it and allowed to remain in it exactly a minute, and as ſoon as the tinge it gave to the paper

paper was decidedly red, it was removed from the fire and meafured; at this time the temperature was 124°. The quantity of water was found to be nine ounces.

Four ounces of Holy-well water were heated to 136°; at this temperature it did not affect the colour of paper ftained with turmeric, and allowed to remain in it one minute. The evaporation was continued in a temperature never exceeding 140°, and gradually leffened to 124°, the flips of paper being ufed at fhort intervals as before. When a decidedly red tinge was obferved, on allowing the paper to remain in it for a minute in a temperature of 124°, it was removed from the fire and meafured: it was found to have loft juft one fourth. From this experiment it is evident the quantity of carbonat of Soda in a gallon of Holy-well water is eafily calculated. The refult is 5,33 grs.

36. Half a grain of carbonat of Soda was diffolved in eleven ounces of diftilled water, and expofed to a temperature of 115°. The paper ftained with turmeric was ufed as before; but I now meafured the water as foon as the leaft difcolouration appeared in the paper after it had remained in it for a minute in the above temperature, and found the quantity to be ten ounces and a half.

Four ounces of Holy-well water difcoloured the paper, allowed to remain in it for the fame

 length

length of time in the ſame temperature, when one eighth was evaporated. I was ſurpriſed, on making the calculation, to find that this experiment gave preciſely the ſame reſult as the preceding, 5,33 grs. of carbonat of Soda in a gallon, that is, 128 ounces.

In making theſe experiments the paper muſt not be allowed to touch the bottom of the veſſel, and it muſt be examined the moment it is taken from the water; elſe the red tinge will appear ſooner than it ought to do, in the former caſe, from the higher temperature of the bottom of the veſſel, and in the latter from the evaporation of part of the water which adheres to the paper by which the alkaline ſolution which remains on it is rendered ſtronger. This increaſe of redneſs, for ſome ſeconds after it is removed from the water, is very obſervable. The redneſs does not continue to increaſe however; and when the paper is dry, unleſs it has been conſiderable, it is no longer to be perceived. The red tinge is more readily obſerved if the wet paper is laid on ſomething white.

37. In order to aſcertain the quantity of carbonat of lime which the Holy-well water contains, a gallon, which had been kept only 24 hours, was evaporated in a temperature below the boiling point in a glaſs retort and receiver, luted together, to two ounces and ſix drams.

The

The diſtillation occupied between three and four days. The water remaining in the retort was then filtered, and the powder which remained on the filter ſubjected to the action of diluted muriatic acid; a conſiderable effervеſcence enſued. The ſame portion of acid was repeatedly paſſed through the paper, and then diſtilled water paſſed through it, till the water came away taſteleſs. The cruſt on the retort was then in like manner ſubjected to the repeated action of diluted muriatic acid, and waſhed repeatedly with ſmall quantities of diſtilled water, in order to obtain the whole of the acid which had been put into the retort: the diluted acid, and the water with which the powder and cruſt in the retort had been waſhed, were put together, and ſome ſulphuric acid (ſp. gr. 1,85) was added to them. They were then evaporated to one half at a low temperature, and at that of 135°, alcohol (ſp. gr. 817) was repeatedly added to them. They were now placed in a temperature of between 60 and 70°, in which they were allowed to remain for 48 hours. At the end of this time a copious depoſition of ſulphat of lime had taken place, which was ſeparated from the fluid by filtering, and dried by expoſure for many hours to a temperature of about 170°. It was now found to weigh 2,5 grs.

Sulphat of lime (according to Mr. Kirwan) dried in a temperature of 170°, conſiſts of 50,39

acid

acid, 35,23 lime, 14,38 water. It requires a white heat wholly to deprive it of water: 2,5 grs. of ſulphat of lime, therefore, contains 0,88 grs. of lime. 100 parts of carbonat of lime (according to Mr. Kirwan) contain 45 of acid and 55 of lime; therefore, 0,88 grs. of lime give 1,6 of carbonat of lime, the quantity contained in a gallon of Holy-well water.

38. In order to aſcertain the quantity of carbonat of magneſia in the Holy-well water, to the water remaining in the retort, in the laſt experiment, after it was filtered, a ſtrong ſolution of ammonia was added; and after it had been allowed to ſtand for twelve hours, it was agitated in the veſſel till all the magneſia that had been depoſited was mixed with the water: it was then filtered to obtain the magneſia, which was diſſolved in diluted muriatic acid, and added to the acid from which the ſulphat of lime was ſeparated in the laſt experiment. A ſolution of Soda was then added to them as long as any precipitate appeared. The magneſia and iron were thus obtained in the form of a reddiſh brown fleecy precipitate, which was allowed to fall towards the bottom of the veſſel, and after pouring off the clear fluid, re-diſſolved in a ſmall quantity of diluted muriatic acid. The iron was then precipitated by pruſſiat of potaſs; and in about twelve hours after, removed by filtering. The fluid now contained nothing capable of

of being precipitated by carbonat of Soda but magnefia. A folution of this carbonat was dropped into it as long as any precipitate appeared, by which the magnefia was obtained in the ftate in which it exifts in the water. It was feparated by filtering, and dried in a temperature of 80° for twelve hours, and found to weigh 1,166 grs. but this includes a fmall quantity of water, for it requires a temperature of 600° to expel from magnefia the whole of its water. Mr. Kirwan has fhewn that 100 grs. of carbonat of magnefia dried at 80° contain 45 of magnefia; therefore, 1,166 grs. of carbonat of magnefia dried at 80° contain 0,524 of magnefia. According to the fame chemift, 79 grs. of carbonat of magnefia contain 34 of acid; therefore, 0,524 grs. of magnefia give of carbonat of magnefia 0,9199 grs. the quantity contained in a gallon of Holy-well water.

39. In order to afcertain the quantity of carbonat of iron in the Holy-well water, a gallon * was evaporated to drynefs in a glafs retort and receiver, luted together, in a temperature below the boiling point. The diftillation occupied between four and five days. A white cruft was left in the part of the retort which the water had occupied. This was fubmitted to the action of diluted muriatic acid; a ftrong effervefcence

* It was brought from the fpring to Worcester, and immediately put into the retort.

vefcence enfued. The acid was repeatedly applied to every part of the retort which the water had touched; and after the acid was poured out, the fame parts were repeatedly wafhed with fmall quantities of diftilled water, which were added to the acid; the whole was then filtered. The acid which remained uncombined was neutralifed by a ftrong folution of ammonia; and this folution was added as long as any precipitate appeared. The precipitate was then feparated by filtering, and rediffolved in diluted muriatic acid : a folution of pruffiat of potafs was then dropped into it as long as any blue precipitate was formed; and this precipitate, after it had ftood about twenty-four hours, was removed by filtering. The paper in which it was obtained had been dried in a temperature of about 70°, and weighed 2 grs. It was again dried in the fame temperature, and found to weigh 2,95; 0,95, then, was the weight of the pruffiat of iron. This pruffiat is compofed of equal quantities of oxide of iron and pruffian acid. The quantity of oxide of iron obtained from a gallon of Holy-well water, then, is 0,475: 100 parts of carbonat of iron contain 24 of acid and 76 of oxide of iron, fo that 0,475 of oxide gives 0,625 of carbonat of iron, the quantity contained in a gallon of Holy-well water.

In eftimating the quantity of iron in mineral

waters,

waters, Mr. Kirwan advifes us to feparate the magnefia, if any exifts, from the iron by acetous acid; but the quantity of both is fo fmall in the prefent cafe that I found it impoffible to eftimate the quantity of iron by this method.

40. Sixty ounces of Holy-well water were kept for a fortnight in a bottle, loofely corked. They were then evaporated, in a glafs retort and receiver, to four ounces; thefe were filtered, and the powder obtained and the film remaining on the retort were treated with diluted muriatic acid, and the whole of the iron diffolved in the acid obtained in the ftate of pruffiat, as in the laft experiment, in a piece of paper weighing gr. 2, and dried in a temperature of about 70°: the paper was again dried in the fame temperature, but the weight of the pruffiat was fo fmall as not to be indicated by a nice balance. It appears, therefore, that the Holy-well water lofes its iron by being kept; but as it holds no more iron in folution than it can hold independently of the prefence of any gas, its iron is loft more flowly than a great portion of the iron of moft other chalybeats.

Sect. 5.

Of the quantity of the Saline contents of the water of the Holy-well.

41. To afcertain the quantity of fulphat of Soda in this water, fixty ounces were flowly evaporated in a glafs retort and receiver, put together

together without luting, to four ounces. Before it was poured out of the retort it was repeatedly paſſed over every part of the retort which the water had touched, during the evaporation, that it might take up any of the ſulphat of Soda which had been left; it was then filtered, and the carbonat of Soda decompoſed, and the Soda ſaturated with acetous acid. A ſolution of acetat of Barytes was then added as long as any precipitate appeared: it was allowed to remain at reſt above twelve hours. The precipitate was then obtained by filtering through a piece of paper, which weighed 2 grs. and had been dried in a temperature of about 70°, more of the ſolution of acetat of Barytes was added to the filtered fluid, but no farther precipitate enſued. The paper was again dried in the ſame temperature; it was now found to weigh 3 grs. The weight of the ſulphat of Barytes, therefore, was 1 gr. Mr. Fourcroy has ſhewn that ſulphat of Barytes, whether native or artificial, contains 0,03 of water; to expel the whole of which requires a red heat: a grain of ſulphat of Barytes, therefore, wholly deprived of its water, gives 0,97 of real ſulphat of Barytes. Now, Mr. Kirwan has ſhewn that 170 grs. of real ſulphat of Barytes indicate 100 grs. of deſiccated ſulphat of Soda; therefore, 0,97 grs. indicate 0,57 of deſiccated ſulphat of Soda, or 1,347 of chryſtalliſed ſulphat of Soda,

Soda, the quantity which exiſts in ſixty ounces of Holy-well water, which makes 2,896 grs. in a gallon.

42. To aſcertain the quantity of muriat of Soda in the Holy-well water, thirty ounces were ſlowly evaporated in a glaſs retort and receiver, put together without luting, to two ounces. Before the water was poured out, it was repeatedly applied to every part of the retort which it had touched during the evaporation. It was then filtered, and the Soda ſaturated with acetous acid, as in the preceding experiment. A ſolution of the acetat of ſilver was now dropped into it, as long as any precipitate appeared. It was allowed to remain at reſt above twelve hours, and filtered through a piece of paper which had been dried in a temperature of about 70°. and weighed 2 grs. The filtered fluid gave no precipitate on the farther addition of acetat of ſilver. The paper was again dried in the ſame temperature, and found to weigh 2,857 grs. 0,857, then, was the weight of the muriat of ſilver. Mr. Kirwan has ſhewn that 235 grs. of muriat of ſilver indicate 100 grs. of muriat of Soda dried at a temperature of 80°. therefore, 0,857 grs. of muriat of ſilver denote 0,364 of muriat of Soda, the quantity contained in thirty ounces, that is, 1,553 grs. in the gallon.

43. I made ſeveral experiments to aſcertain the quantity of the reſiduum, (24,25.) from which it appears that it forms about one-third of the powder obtained by evaporation to about one-twelfth part, beſides the film which remains on the retort after the action of the acid, which amounts, perhaps, to about one half as much as the part of the reſiduum found in the powder. This makes the quantity of reſiduum in a gallon 1,687 grs.

The contents of a gallon of the Holy-well water, then, are,

Carbonat of Soda	5,33 grs.
Carbonat of lime	1,6
Carbonat of magneſia . .	0,9199
Carbonat of iron . . .	0,625
Sulphat of Soda . . .	2,896
Muriat of Soda . . .	1,553
Reſiduum	1,687
	14,6109

CHAP. II.

CHAP. II.

OF THE WATER OF ST. ANN'S WELL.

IN the Analyſis of the water of St. Ann's-well, I ſhall follow the ſame plan which was purſued in that of the Holy-well; but as moſt of the experiments I am about to relate are ſimilar to thoſe which have already been laid before the reader, it will not be neceſſary to detail them with the ſame minuteneſs.

SECT. 1.

Of the Gaſeous contents of the water of St. Ann's well.

44. Lime water was mixed with the water of St. Ann's well, in equal quantities, at the ſpring; but I did not perceive that the tranſparency was at all diſturbed, either at the time of mixing them or for ſome time after: nor did I perceive any of the flocculi obſerved when the Holy-well water was mixed with lime water. (1.)

45. Strontian water was mixed with the water of St. Ann's well, in equal quantities, at the ſpring: in a ſhort time they became turbid, but not to the ſame degree as the Holy-well water and Strontian water.

45. Barytic water was mixed with it, in equal quantities,

quantities, at the ſpring: the turbidneſs became greater than in the laſt experiment, but not equal to what it was when the Holy-well water was uſed.

47. To the water at the ſpring a few drops of a ſtrong ſolution of litmus were added, ſo as to give the whole a ſlight tinge: the litmus was not at all reddened; it had exactly the ſame appearance as if the infuſion had been dropped into diſtilled water.

48. Into a glaſs veſſel, connected by means of a glaſs tube with a mercurial apparatus for the purpoſe of examining the nature of gaſes, eight ounces of the water of St. Ann's well were put at the ſpring, the whole contents of the veſſel and tube being twelve ounces and three drams. The experiment was conducted preciſely in the ſame way with a ſimilar experiment mentioned above, (7.) and the reſult was the ſame: the ſame ſolution of potaſs uſed in that experiment was introduced into the jar which received the air which had come over from the veſſel containing the water; but although it was ſtrongly agitated with it for a conſiderable length of time, no abſorption whatever took place. The jar was removed into a tub of water, and an equal volume of nitrous gas mixed with the air it contained; nitrous acid was formed, and, on agitation, the water roſe to the ſame point of the ſcale attached to the jar which it had occupied before the introduction of the nitrous

nitrous gas. The whole of the air contained in the jar, consequently, was atmospherical air.

The water in St. Ann's well, therefore, contains no carbonic gas; the precipitate occasioned by the Barytic and Strontian water, then, must arise from some other part of its contents.

SECT. 2.

Of the carbonats contained in the water of St. Ann's well.

49. A dilute infusion of litmus prepared with filtered rain water was sensibly reddened by a very small quantity of acetous acid; it was then divided into two equal parts; to the one was added a certain quantity of filtered rain water, to the other the same quantity of the water of St. Ann's well, which had been kept for some time. The latter appeared of a bluer colour than the other.

49. Into this water at the spring and filtered rain water, a little of an infusion of litmus, reddened by an acid, was dropped. The water of St. Ann's well soon assumed a bluer colour than the other.

51. Into Holy-well water, and water of St. Ann's well, both at the spring, a little of an infusion of litmus, reddened by an acid, was dropped. The former assumed a bluer colour than the latter. From this experiment it appears, that the water of St. Ann's well does not possess so great a power of neutralizing acids as that of the Holy-well.

52. Three

52. Three pints of the water of St. Ann's well were evaporated in a glaſs retort and receiver to about four ounces, and filtered to ſeparate the powder which had been depoſited: this powder was ſubjected to the action of diluted muriatic acid: a conſiderable effervefcence enſued. The acid was then filtered, and ſome ſtrong ſulphuric acid was added to it; a cloud appeared, which was much increaſed on the addition of alcohol. The water of St. Ann's well, therefore, contains carbonat of lime.

53 The acid uſed in the preceding experiment was filtered, to ſeparate from it the ſulphat of lime, and a ſolution of pruſſiat of potaſs was dropped into it; a blue precipitate was immediately formed: from which it appears, that the water of St. Ann's well, like that of the Holy-well, contains iron. This water itſelf, however, gives no indication of iron, either at the ſpring or after part of it has been evaporated, however far the evaporation has been carried. (14.)

54. A part of the powder obtained by evaporating two gallons of the water of St. Ann's well to twelve ounces, was ſubjected to the action of diluted muriatic acid: the acid was then filtered, and a ſtrong ſolution of ammonia dropped into it: a whitiſh fleecy precipitate was formed. This water, therefore, alſo contains carbonat of magneſia.

54. The water which remained in the retort

in

in the diſtillation laſt mentioned, reddened paper ſtained with turmeric, indicating the preſence of an alkaline carbonat. (17.)

55. The preſence of an alkaline carbonat was alſo proved by finding that when the water was evaporated to a 15th or 16th part, its power of neutralizing acids was greatly increaſed. (18.)

56. About thirty-five ounces of this water were ſlowly evaporated to two, in a glaſs retort and receiver, it was then filtered and evaporated in an open glaſs veſſel, with a temperature below the boiling point, to one dram, care having been taken that no part of the alkaline carbonat ſhould be left on the ſides of the retort in which the diſtillation was performed. A ſolution of tartareous acid (ſp. gr. 1,56) was then freely added, but no preciptation of ſupertartrite of potaſs took place. It was then evaporated to dryneſs, but no ſupertartrite of potaſs was depoſited. The alkaline carbonat of the water of St. Ann's well, therefore, is the carbonat of Soda.

From the foregoing experiments it appears that the water of St. Ann's well contains all the carbonats found in that of the Holy-well, namely, the carbonats of Soda, lime, magneſia and iron.

57. The film which adheres to the retort is of the ſame nature with the powder which floats in the

the water. It was ſubjected to the ſame proceſses as the powder, and yielded lime, magneſia and iron. (12, 13, 15.)

The reſiduum left by the muriatic acid has the ſame properties with that obtained from the water of the Holy-well. (25).

Sect. 3.

Of the Saline contents of the water of St. Ann's well.

58. A few drops of a ſolution of nitrat of Barytes was added to this water at the ſpring. No precipitate or cloud enſued.

59. Three pints were evaporated in a glaſs retort to about four ounces, and filtered: to a part of it more nitrous acid was added than was ſufficient to ſaturate the Soda it contained; a ſolution of nitrat of Barytes was then dropped into it. A white precipitate was immediately formed.

From theſe experiments it appears, that the water of St. Ann's well contains ſulphuric acid, but not in conſiderable quantity.

60. To two ounces of this water, without previous diſtillation, more nitrous acid was added than was neceſſary to ſaturate the Soda it contains: a ſolution of nitrat of ſilver was then dropped into it. A cloud immediately appeared, demonſtrating the preſence of muriatic acid.

61. A quart of it was evaporated in a glaſs retort

retort and receiver to about two ounces, and deprived of its ſulphuric and muriatic acid by ſolutions of acetat of Barytes and of acetat of ſilver. (29.) It was then evaporated to dryneſs, and the acetats were diſſolved by alcohol; ſulphuric acid was added to the reſiduum; but no nitric acid was diſengaged. From this experiment it appears that the water of St. Ann's well contains no nitric acid.

This water, therefore, like the Holy-well water contains only the ſulphuric and muriatic acids; for it appears from the obſervations made above, (C. 1. S. 3.) that it is only theſe, or the nitric acid, that we are to look for in it, ſince it contains no diſengaged acid, which is proved by the experiments related in the laſt Section. It remains to be aſcertained to what baſis the foregoing acids are united.

I have already had occaſion to obſerve, that under the firſt head in Mr. Kirwan's Table of incompatible ſalts, alkaline carbonats are mentioned as incompatible with earthy or metallic ſulphats, muriats, or nitrats. To this we found there is one exception, as ſmall quantities of ſulphat of lime ſometimes exiſt in mineral waters with ſuch carbonats. To aſcertain whether the water of St. Ann's well contains ſulphat of lime, the following experiment was made.

62. Some of this water was boiled till a ſlight

degree of turbidnefs appeared; it was then filtered, and the evaporation continued till it was reduced to a tenth part. More nitrous acid than was fufficient to faturate the Soda it contained, was then added to it; a folution of nitrat of Barytes was now found to occafion as copious a precipitate from it as if it had not been filtered. No part of the fulphuric acid found in this water after partial evaporation, therefore, is derived from that part of its contents which is firft precipitated by boiling. (29, 30.)

It follows, then, from what has been faid, that the foregoing acids are combined with an alkali.

63. Thirty-five ounces of this water were evaporated in a glafs retort and receiver to two, fome lime was then added to it, and to the firft half dram which came over after the addition of the lime, a few drops of a folution of acetat of lead were added; no cloud or precipitate enfued. The alkali with which thefe acids are combined, therefore, is a fixed alkali.

64. Thirty-five ounces of this water were evaporated in a glafs retort and receiver to two, and filtered, care being taken to prevent any part of the foluble contents of the water from remaining on the fides of the veffel in which the evaporation was performed; more acetous acid than was fufficient to faturate the Soda contained in it was then added, and a folution of acetat of

Barytes

Barytes dropped into it as long as any precipitate appeared. It was again filtered to feparate the fulphat of Barytes, and, in an open glafs veffel, evaporated in a temperature below the boiling point to one dram. A folution of tartareous acid (fp. gr. 1,56) was now freely added to it; a precipitation of tartrite of Barytes immediately took place, owing to the water containing fome acetat of Barytes, but no fupertartrite of potafs was formed. It was then filtered and evaporated to drynefs without the formation of any fupertartrite of potafs. The alkali combined with the fulphuric acid, therefore, is not potafs.

65. Thirty-five ounces of water were evaporated in the fame manner to two, and filtered; more acetous acid than was neceffary to faturate the Soda it contained was then added to it, and a folution of acetat of filver dropped into it: a copious precipitate appeared. It was again filtered to feparate the muriat of filver, and evaporated, as in the laft experiment, in an open glafs veffel to about one dram; the fame folution of tartareous acid was then freely added to it; but no precipitate of fupertartrite of potafs enfued. It was then evaporated to drynefs without any fupertartrite of potafs being formed. The alkali combined with the muriatic acid, therefore, is not potafs.

From all the experiments which have been related in this Chapter, it appears, that the contents,

tents of the water of St. Ann's well are the ſame as thoſe of the Holy-well water; namely, the carbonats of Soda, lime, magneſia and iron, the ſulphat and muriat of Soda, and the reſiduum, whoſe properties are mentioned above, (25).

Sect. 4.

Of the quantity of the Carbonats of the water of St. Ann's well.

66. Two ounces of this water were evaporated in a glaſs retort to one. In a temperature of 124°, paper ſtained with turmeric was allowed to remain in it for a minute. At the end of this time it had a decidedly red tinge.

This experiment was repeated with eight ounces, and with half a gallon of water, and the reſult ſtill found to be the ſame.*

* The evaporation in this case was performed in a retort, not in an open vessel, as in a similar experiment related above, (35.) because I found from many trials, that by evaporation for so long a time as was here necessary, in open vessels, even with a very low temperature, a considerable part of the carbonat of Soda was dissipated. We have seen above, (21, 22.) how readily this carbonat rises with the water. The cause of the difference of the result in evaporating in close and open vessels, seems to be, that in the latter case all that rises from the water escapes; in the former only the most volatile parts, the other parts being condensed on the sides of the retort return to the fluid; hence the advantage of distilling in retorts, whose contents are much larger than the quantity of fluid we wish to distill. In this way we may easily account for Dr. J. Wall's having found so little residuum when he evaporated the Holy-well water in an open vessel.

If

If thefe experiments be compared with one related above, (35.) in which half a grain of carbonat of Soda, in nine ounces of water, gave a fimilar tinge to paper ftained with turmeric, the quantity of carbonat of Soda in a gallon of the water of St. Ann's well, will be found to be 3,55 grs.

67. In order to afcertain the quantity of the other carbonats which this water contains, a gallon * was evaporated to drynefs in a temperature below the boiling point in a glafs retort and receiver, luted together. The diftillation occupied between four and five days. A white cruft remained in the bottom of the retort, which was fubjected to the action of diluted muriatic acid. A confiderable effervefcence enfued. The acid was repeatedly applied to every part of the retort which the water had touched, and after the acid was poured out the fame parts were repeatedly wafhed with diftilled water, that the whole of the acid which had been put into the retort might be obtained. Thefe portions of water were added to the acid, and fome fulphuric acid (fp. gr. 1,85) was dropped into them. The whole was then evaporated in a temperature below the boiling point to about one-third, and in that of 135°, alcohol (fp. gr. 0,817) was repeatedly dropped into it. It was now placed in a temperature of about 60°, where

* It was brought from the spring to Worcester, and immediately put into the retort.

it

it was allowed to remain for forty-eight hours; during this time a depofition of fulphat of lime had taken place, which was feparated by filtering through a piece of paper which weighed 2 grs. and had been dried in a temperature of about 60°. It was again dried in the fame temperature, and found to weigh 2,55 grs.

We found above, (37.) that 2,5 grs. of fulphat of lime indicate 1,6 grs. of carbonat of lime; 0,55 grs. therefore, indicate 0,352 grs. of carbonat of lime, the quantity in a gallon of the water of St. Ann's well.

68. In order to eftimate the quantity of carbonat of magnefia in this water, to the fluid from which the fulphat of lime had been feparated in the preceding experiment, pruffiat of potafs was added as long as any blue precipitate appeared, which, after being allowed to ftand for 24 hours, was feparated by filtering.

The filtered fluid now contained nothing capable of being precipitated by carbonat of Soda but magnefia; a folution of this carbonat, therefore, was dropped into it as long as any precipitate appeared; the magnefia was thus obtained in the ftate of a carbonat, in which ftate it exifts in the water. After it had flood above twelve hours, it was feparated by filtering through a piece of paper, weighing 2 grs. which had been dried in a temperature of 80°; the paper was again dried in the fame temperature, and found

to

to weigh 2,33. But the carbonat of magneſia dried at 80°, we have ſeen, contains a certain portion of water. It appears from what is ſaid above, (38.) that 1,166 grs. of carbonat of magneſia, dried at 80°, indicate, of real carbonat of magneſia, 0,9199 grs. therefore, 0,33 grs. indicate 0,26 grs. of real carbonat of magueſia, the quantity in a gallon of the water of St. Ann's-well.

69. In order to eſtimate the quantity of carbonat of iron in the water of St. Ann's well, the precipitate formed by the pruſſiat of potaſs, in the preceding experiment, was obtained in a piece of paper which weighed 2 grs. and had been dried in a temperature of about 60°: it was again dried in the ſame temperature, and found to weigh 2,5 grs.

It was found above, (39.) that 0,95 grs. of pruſſiat of iron indicate 0,625 of carbonat of iron; therefore, 0,5 grs. of pruſſiat of iron indicate 0,328 grs. of carbonat of iron, the quantity in a gallon of the water of St. Ann's well.

It is almoſt ſuperfluous to obſerve, that the water of St. Ann's well, like that of the Holywell, loſes its iron by being kept.

It may be proper to mention, that the foregoing precipitates, and the papers in which they had been obtained, were waſhed with diſtilled water before they were dried. If this is not done,

done, ſome of the other contents of the fluid will adhere to the paper.

Sect. 5.

Of the quantity of the Saline contents of the water of St. Ann's well.

70. In order to eſtimate the quantity of ſulphat of Soda in this water, half a gallon was ſlowly evaporated to four ounces in a glaſs retort and receiver. Before it was poured out of the retort, the water was repeatedly applied to every part which it had touched during the evaporation. A ſufficient quantity of acetous acid was then added to it to ſaturate the Soda, and a ſolution of acetat of Barytes was dropped into it as long as any precipitate appeared. It was allowed to ſtand above twelve hours, and then filtered through a piece of paper, which had been dried in a temperature of about 60°, and weighed 2 grs. To the filtered fluid, more of the ſolution of acetat of Barytes was added; but no farther precipitate took place: the paper was again dried in a temperature of about 60°, and found to weigh 2,55 grs. Had a whole gallon of water been uſed, therefore, the weight would have been 3,1 grs.

It was ſhewn above, that 1 gr. of ſulphat of Barytes, dried in the common temperature of the air, indicates 1,347 grs. of chryſtalliſed ſul-

phat

phat of Soda; therefore, 1,1 grs. of ſulphat of Barytes indicate 1,48 grs. of ſulphat of Soda, the quantity in a gallon of the water of St. Ann's well.

71. In order to aſcertain the quantity of muriat of Soda in this water, to the water uſed in the laſt experiment, after the ſulphat of Barytes was ſeparated by filtering, a ſolution of acetat of ſilver was added as long as any precipitate appeared. It was allowed to ſtand for more than twelve hours, and was then filtered through a piece of paper of the ſame weight, and which had been dried in the ſame temperature with that uſed in the laſt experiment. It was again dried in this temperature, and found to weigh 3,125 grs. To the filtered water, more acetat of ſilver was added; but no farther precipitate appeared. Had a whole gallon of water been uſed, therefore, the quantity of muriat of ſilver would have been 2,25 grs. It was ſhewn above, that 0,857 grs. of muriat of ſilver indicate 0,364 grs. of muriat of Soda; therefore, 2,25 grs. of muriat of ſilver indicate 0,955 grs. of muriat of Soda, the quantity in a gallon of the water of St. Ann's well.

72. The reſiduum left after the action of the diluted muriatic acid on the precipitate obtained by evaporation, ſeems to bear the ſame proportion to the carbonats as that obtained from the Holy-well water; and, on this ſuppoſition, amounts to 0,47 grs.

The following, then, are the contents of the water of St. Ann's well:

Of carbonat of Soda -	3,55 grs.
Of carbonat of lime, -	0,352
Of carbonat of magnesia	0,26
Of carbonat of iron -	0,328
Of sulphat of Soda -	1,48
Of muriat of Soda -	0,955
Of residuum - - -	0,47
	7,395

CHAP. III.

CHAP. III.

OF THE MEDICINAL EFFECTS OF THE MALVERN WATERS.

As the following obſervations concern the public at large, equally with the chemiſt, I ſhall lay aſide the language peculiar to the latter, which may here be done, as the few ſubſtances I ſhall have occaſion to mention are ſuch as are commonly known.

The general reader will underſtand many of the terms uſed in the preceding Chapters, and have a clearer knowledge of what I am about to ſay, when the terms carbonic gas and carbonat are explained to him, which may be done in a few words. By carbonic gas, the chemiſt means fixed air. This air is an acid, which, like every other, has a tendency to unite with certain ſubſtances when it is brought into contact with them. When it is united to any other ſubſtance, chemiſts call the compound, a carbonat, as the carbonat of Soda, of iron, &c. *

It

* When it enters into combination, it loses the form of an air, which, however, it immediately assumes if it is displaced by a stronger acid, or any other cause; hence the effervescence which ensues

It appears from the foregoing Analyſis, that the Malvern waters differ from the other celebrated waters of Britain, and agree with ſeveral of thoſe of the continent in containing carbonat of Soda. To the Spa water they bear ſo ſtriking a reſemblance, that the ſolid contents of theſe waters differ in little elſe than the greater proportion in which they exiſt in the Spa water, as the reader will perceive from the following Table of the ſolid contents of a gallon of the Malvern and Spa waters. The proportion of the contents of the Spa water is taken from the Analyſis of Bergman, reduced to the Engliſh meaſure by Dr. Saunders in his Treatiſe on Mineral Waters:—

ensues when we mix a solution of carbonat of Soda with lemon juice in making the common saline draught, or drop lemon juice on chalk, which is the carbonat of lime. From the property of being, as it were, fixed in bodies with which it combines, it was in a less perfect state of chemistry, when this property was supposed to be peculiar to it called fixed, or fixable air, chemists do not allow it the name of air or gas, their term for air, except when it exists in an aereform state. The cause of this requisite distinction in chemistry, it is not necessary here to enter on. After the explanation I have given, I shall be allowed in the present Chapter to call it fixed air, whether it exists in the aereform or fixed state.

	Holy-well.	*St. Ann's.*	*Spa.*
	GRS.	GRS.	GRS.
Soda, combined with fixed air	5,33	3,55	11,76
Lime, combined with fixed air, *i. e.* chalk	1,6	0,352	11,76
Magnefia, combined with fixed air, *i. e.* uncalcined magnefia	0,9199	0,26	35,68
Calx of iron, combined with fixed air, *i. e.* ruft of iron	0,625	0,328	5,86 *
Glauber falt	2,896	1,48	
Common falt	1,553	0,955	1,376

——000——

* Dr. Saunders gives the quantity of calx of iron: I here give the quantity of calx saturated with fixed air.

The

The ſolid contents of the Malvern and Spa waters, it appears from the foregoing Table, if we except the difference in quantity, differ only in there being no Glauber ſalt in the Spa water. The Spa water differs alſo from the Malvern waters in containing a conſiderable quantity of uncombined fixed air, none of which is contained in the Malvern waters.

How far the effects of the Spa water depend on the preſence of the uncombined fixed air we cannot ſay; we ſhould not be inclined to attribute much of them to this air, becauſe water as much or more charged with it is not found to produce the ſame effects; but a ſimilar obſervation applies to every other ingredient of theſe waters. The effects of mineral waters do not ſeem to ariſe from any one of their contents, ſo much as from the peculiar combination and manner in which they exiſt in the waters. We cannot infer that all waters having any one ingredient, although their moſt active ingredient, the ſame will produce ſimilar effects; but we certainly have reaſon to expect ſimilar effects from waters, the greater part of whoſe moſt active ingredients are the ſame, and exiſt in them in the ſame ſtate. Whether the Malvern waters will be found ſerviceable in the various caſes in which the Spa water is ſo celebrated, it is impoſſible to ſay, as a trial of them in many of theſe caſes has not been made; but that they

are

are calculated to produce fimilar effects in relaxation of the fyftem, and the various difeafes which arife from it, is probable from their effects in fcrophulous debility, which are perhaps more beneficial than thofe of any other mineral water of this country. The fmaller quantity of the foreign contents, which, however, is in fome meafure compenfated by the Malvern waters being ufed in greater quantity than the Spa water, will probably render them lefs effectual than the latter in many cafes; but it is not unlikely that from the fame circumftance they may be better adapted to others, and they derive from it no fmall advantage in being perfectly fafe. A trial of them, though often attended with fome inconvenience, never produces any ferious bad effects.

In eftimating the probable virtues of a mineral water, we muft not attend fo much to the mafs of its folid contents as to the activity of thefe contents. Many waters in common ufe contain a much larger proportion of folid contents than fome of the moft powerful mineral waters. Of the ingredients found in mineral waters iron and Soda are among the moft active; and the reader will obferve from the foregoing table, that the difference of the quantities of thefe in the Malvern and Spa waters is not fo great as of fome other of their contents. The folid contents of the Buxton water, though rather

ther more than thofe of the Holy-well, may almoft, perhaps, from the inactivity of their nature and their fimilarity to the contents of many waters in common ufe, be overlooked in explaining its effects, Writers have confequently, with great probability, attributed thefe effects to an air of a peculiar kind which it contains. The effects of the Tunbridge water, on the contrary, are attributed chiefly to its folid contents, although the whole of thefe, according to Dr. Babington's Analyfis, amount only to 5 grs. in a wine gallon; about a third part of the folid contents of the Holy-well water. But one grain is calx of iron.

The fenfible effects of the Malvern waters are different in different cafes, and they are generally moft felt on firft ufing the waters. It is not uncommon for them to produce a degree of naufea, and they often prove aperient, fometimes confiderably fo; in many cafes they produce the oppofite effect on the bowels, so that fome aperient medicine is neceffary. When drank largely, particularly by thofe who are not accuftomed to them, they frequently produce fome vertigo, drowfinefs, or even pain of the head. In fome they produce a degree of feverifh heat. I have known many inftances in which it was neceffary to lay afide the ufe of them on this account. The moft conftant of all their

fenfible

fenfible effects is that of a diuretic, and they feldom fail, after they have been ufed for fome time, to encreafe both the fpirits and appetite.

To what part of their contents each of thefe effects are to be afcribed, it is difficult to fay pofitively: many of them feem to arife from the iron they contain. That the increafed heat proceeds from this caufe cannot, I think, be doubted; and it is remarkable that many of the other effects which have been enumerated, are the fame which attend the ufe of other chalybeates. Many of the effects of the Tunbridge water, for example, although more powerful in proportion as it is a ftronger chalybeate, are fimilar to thofe juft mentioned. It alfo produces naufea, drowfinefs, and vertigo, which, as in the cafe of the Malvern waters, are moft felt on firft ufing it.

Dr. J. Wall's explanation of thefe effects, though ingenious, can hardly, I think, be admitted. He fuppofes that they arife from the great purity of this water, in confequence of which it enters the veffels very rapidly, and thus produces a temporary plethora. But it appears from all that has been faid, that the Malvern waters, particularly the water of the Holy-well, are by no means fo free from foreign contents as has been fuppofed. Befides, were this explanation juft, diftilled water ought to produce a greater degree of the fame fymptoms, which is not found to be the cafe.

The diuretic effect, probably one of the moſt beneficial effects of theſe waters, we cannot heſitate to aſcribe to the carbonat of Soda, which has long been uſed in medicine for the purpoſe of producing this effect, although in the artificial forms in which it is given, it is ſeldom ſo effectual a diuretic as the Malvern waters are. In theſe it is doubtleſs aſſiſted by the large quantity of water in which it is taken, probably by ſome other part of their contents. To this effect, and to the iron which the Malvern waters contain, we may partly aſcribe the good appetite and ſpirits which attend their uſe. Theſe muſt in ſome meaſure be aſcribed to the pleaſant ſituation, and the pure air of the Malvern hills. The quantity of the carbonats of lime and magneſia, and of the ſalts found in theſe waters, ſeems too ſmall to permit us to attribute any of their ſenſible effects to them. They may perhaps modify the effects of the other ingredients in a way we do not underſtand.

I had occaſion in the Introduction to mention the diſeaſes in which the Malvern waters have been chiefly celebrated, namely, the various forms of ſcrophula, cutaneous diſeaſes of different kinds, and gravel. In ſcrophula and cutaneous diſeaſes, Soda and iron have long been celebrated medicines; and on Soda, in ſome form or other, we chiefly rely for relief in gravel. The

The Malvern waters ſeem to be better adapted to the two former caſes than to gravel, becauſe they depend more immediately on the fault of the habit in general, in which we find that minute quantities of medicines, given frequently and for a conſiderable length of time, are often more efficacious than larger doſes. Such, however, is the relief often obtained by theſe waters in gravel, probably in part from their acting merely as a diluent, and in part from the Soda they contain, that Dr. J. Wall thought they poſſeſſed the power of diſſolving urinary concretions. " It is, perhaps, too much to expect," he obſerves, " that a formed ſtone can be diſſolved by this " water; but that ſabulous matter may, I am " fully convinced, from the effects I have ob- " ſerved in thoſe who have uſed it." That it may tend to waſh out ſand lodged in the kidneys, and to prevent its formation, ſeems highly probable, and there is reaſon to believe that it has ſome degree of the effect of waters more ſtrongly impregnated with Soda, which ſeem often to allay the irritation occaſioned by urinary concretions, even where they have no effect in diſſolving them. That a weak chalybeate impregnated with carbonat of Soda, which paſſes off ſo freely by the kidneys, ſhould allay a variety of other diſorders of the urinary paſſages, which Dr. J. Wall ſays he has found it to do, cannot appear ſurpriſing.

Wherever

Wherever there are ſores or eruptions, theſe waters ſhould be uſed externally as well as internally. Indeed, like many other mineral waters, the Malvern waters were at firſt only uſed as an external application. Their good effects, employed in this way, are chiefly to be aſcribed to the carbonat of Soda they contain; a ſimple ſolution of which, applied externally, has long been uſed as a remedy in the ſame diſeaſes.

FINIS.

PRINTED BY J. TYMBS,
WORCESTER.